

Real-time Land Information System over the Continental U.S. for Situational Awareness and Local Numerical Weather Prediction Applications

Jonathan L. Case^{1*}, Kristopher D. White², Brian Guyer³, Jim Meyer⁴,
Jayanthi Srikishen⁵, Clay Blankenship⁵ and Bradley T. Zavodsky⁶,
NASA/Short-term Prediction Research and Transition (SPoRT) Center

^{1*}ENSCO, Inc.; ²NOAA/National Weather Service (NWS) Huntsville, AL; ³NOAA/NWS Albuquerque, NM;
⁴NOAA/NWS Tucson, AZ; ⁵Universities Space Research Association; ⁶NASA/Marshall Space Flight Center

Presentation 3.3; 12 Jan 2016; 30th Conf. Hydrology; 96th AMS annual meeting; New Orleans, LA
Session on Hydrometeorological applications, products and services in service to society

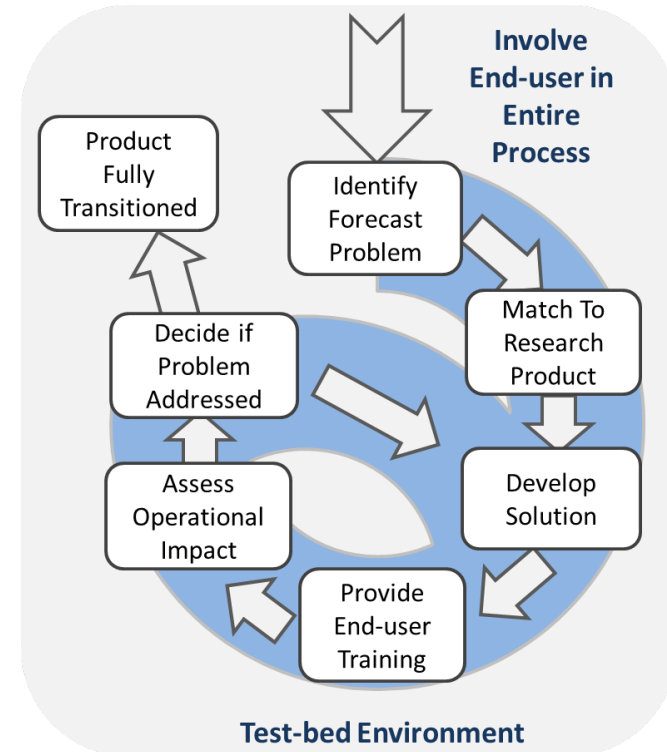
Motivation and Presentation Outline

- **Motivation: high-resolution, real-time soil moisture for**
 - Situational awareness (assessing drought/flood potential)
 - Local modeling applications (to improve sfc-PBL exchanges)
- **Land Information System (LIS)**
 - 30+ year soil moisture climatology & percentile product
 - LIS background and NASA/SPoRT-LIS real-time Noah LSM
 - Evaluation at NOAA/NWS forecast offices
- **Examples from 2015 summer evaluation**
- **Future work:**
 - Real-time soil moisture data assimilation with SMAP / SMOS
 - National Water Center collaborations

NASA/SPoRT Center

Short-term Prediction Research and Transition (SPoRT)

- Transitions unique NASA and NOAA observations and research capabilities to the operational weather community to improve short-term weather forecasts on regional and local scales
- ***Proven paradigm for transition of research and experimental data to operations***
- Close collaboration with numerous NWS WFOs across the U.S.
- Began in 2002; co-funded by NOAA since 2009 through “proving ground” activities



Land Information System (LIS)

LIS modes of operation

Uncoupled or
Analysis Mode

LIS - OPT/UE

Optimization and Uncertainty Estimation
(LM, GA, RW-MCMC, DEMC)

LIS - DA

Data Assimilation (DI, EnKF)

Coupled or
Forecast Mode

LIS - WRF
Interface

Observations (Soil
Moisture, Snow, Skin
Temperature)

Water and Energy
Fluxes, Soil Moisture and
Temperature profiles,
Land surface states

Hydrologic
Forecasts

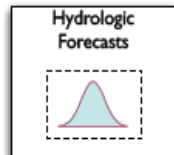
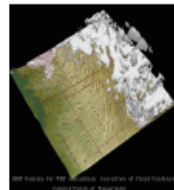
WRF

States (Soil Moisture,
Snow, Skin
Temperature)

Parameters
(Topography, Soil
properties, vegetation
properties)

Meteorological
Boundary Conditions
(Forcings)

Land Surface Models (Noah,
CLM, Catchment, JULES,
TESSEL, HySSIB, Sacramento,
SNOW17)



High-performance land
surface modeling & data
assimilation system

Uncoupled/analysis mode

Forecast mode coupled
to WRF model

We run Noah LSM v3.3 in
uncoupled/analysis mode

LIS-Noah 33-yr Soil Moisture Climatology

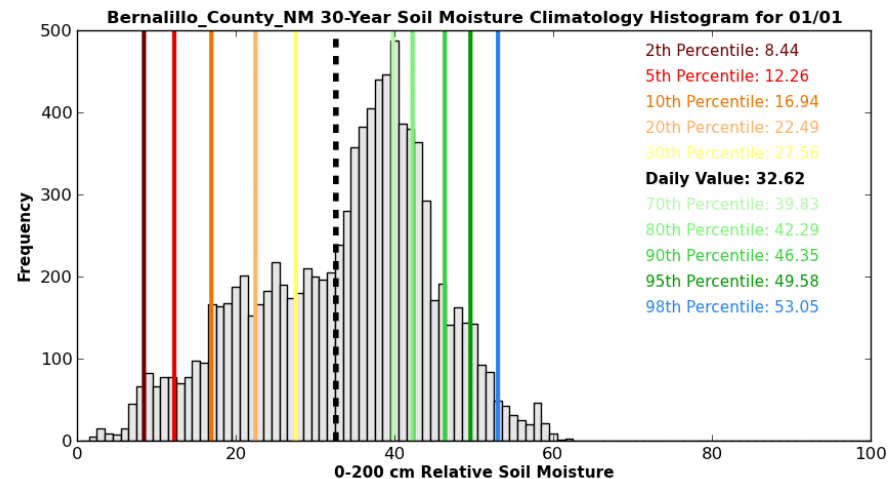
LIS-Noah run from 1981 to 2013

- CONUS+ domain at 0.03-deg resolution (~3 km)
- IGBP/MODIS 20-class land use, STATSGO 16-class soil
- MODIS/FPAR 30-sec resolution monthly GVF climatology (Barlage; from community WRF v3.5.1+)
- Atmos. forcing: NARR-based NLDAS-2 hourly data
- 35-year spin-up (1979-2013, back to 1979-1980)
- Output total column relative soil moisture (RSM) once daily

Daily climatology for every CONUS county

- Basis of RSM percentile product
- Poster 88 in 30th Hydro; Zavodsky et al.; Mon PM session

(right) Animation of daily total column relative soil moisture distribution for Bernalillo county, NM (Albuquerque), with 2014 values in bold dash line.



SPoRT Real-time LIS Running Noah LSM

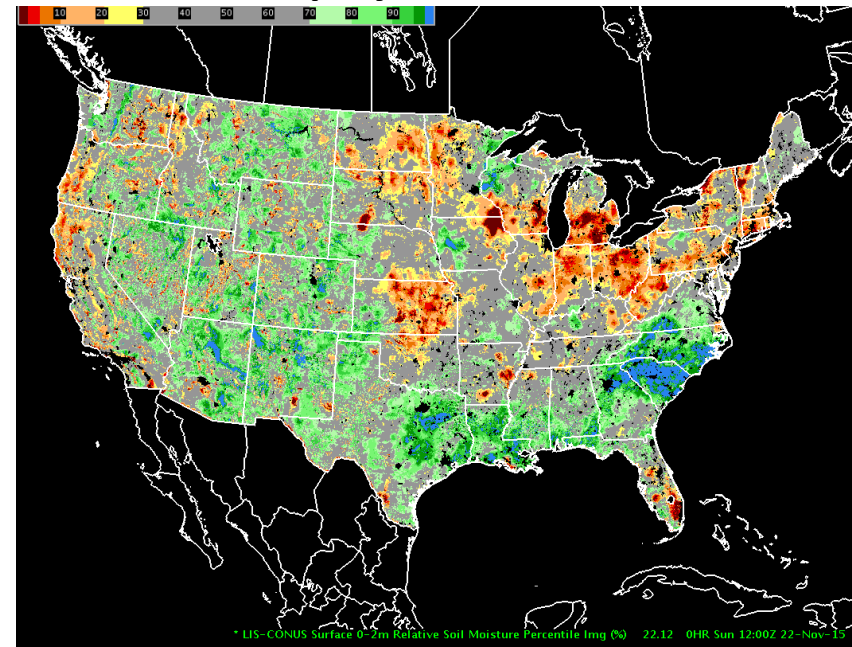
Full Continental U.S. (CONUS) domain with
0.03° (lat/lon) grid resolution

Restarted from soil moisture climatology

Unique characteristics of SPoRT-LIS:

- Real-time S-NPP/VIIRS Green Vegetation Fraction
- Albedo scaled to input vegetation
- Restart simulation strategy to produce real-time output (timeline below)
- SPoRT-LIS ingested and displayed in AWIPS II at select NOAA/NWS weather forecast offices
- Land surface variables available to initialize modeling applications (WRF and STRC/EMS/UEMS)

Current SPoRT-LIS CONUS domain,
as displayed in AWIPS II



transitioning research data to the operational weather community

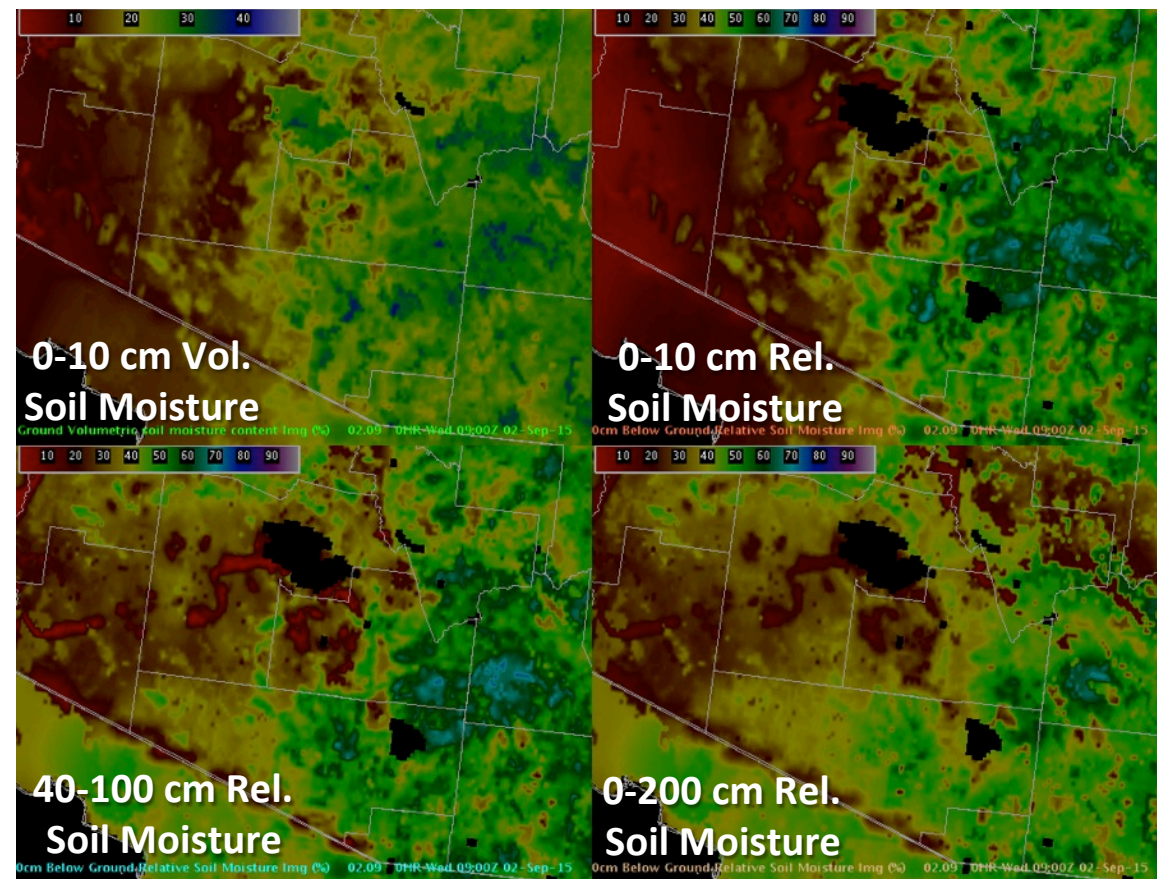


SPoRT-LIS Evaluation: Jun-Aug 2015

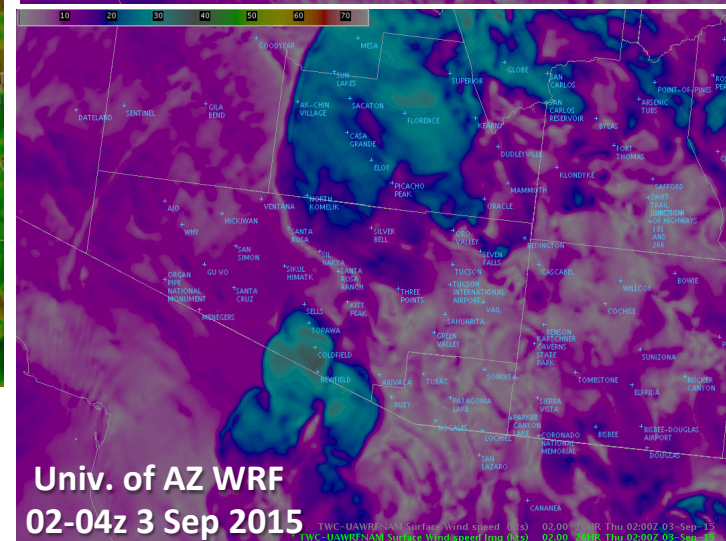
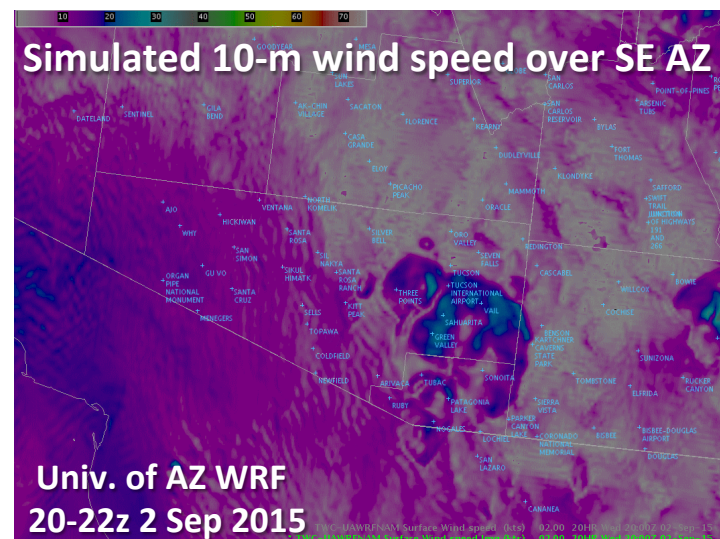
SPoRT-LIS for improving situational awareness

- NWS forecast offices at Tucson, Albuquerque, and Huntsville
- Part of Summer 2015 evaluation focused on GPM/IMERG precipitation products (see Smith et al. talk 9.6, 30th Hydro, Thursday 2:45pm)
- Disseminated select soil moisture grids and change fields
- Forecaster surveys and blog posts to highlight product utility
- Applications included:
 - Assessing drought and USDM drought categories
 - Monitoring soil moisture to help evaluate flooding concerns
 - Examining soil moisture around wildfires
 - Evaluating risk for blowing dust from convective outflows

SPoRT-LIS Evaluation: Flooding and Blowing Dust Outlooks (NWS TWC)



(above) SPoRT-LIS at 09z 2 Sep 2015, as displayed in
NWS Tucson, AZ operational AWIPS II

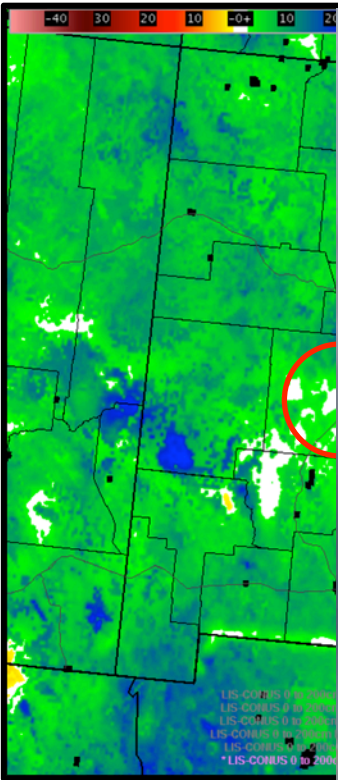


transitioning research data to the operational weather community

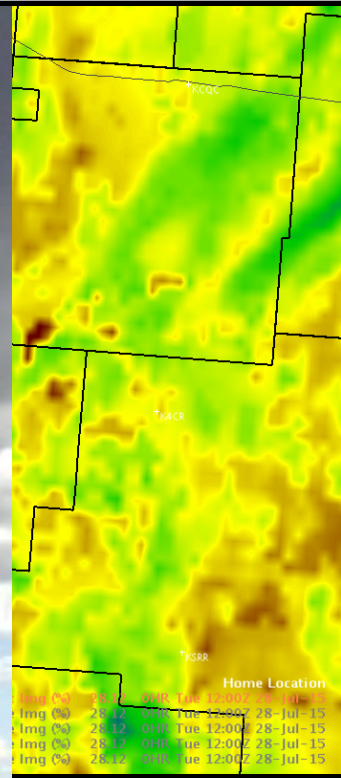


SPoRT-LIS Evaluation:

Soil Moisture Associated with Wildfire (NWS ABQ)



Fort Craig, NM wildfire at 830am 27 July 2015. Wildfire grew to ~700 acres over 2 days.



(left) 1-yr change in
soil moisture, valid
NWS Albuquerque, NM operational AvvIPS II.

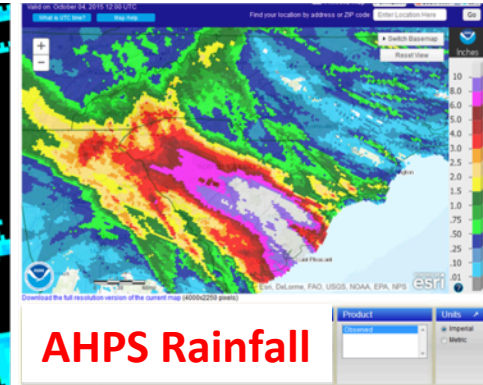
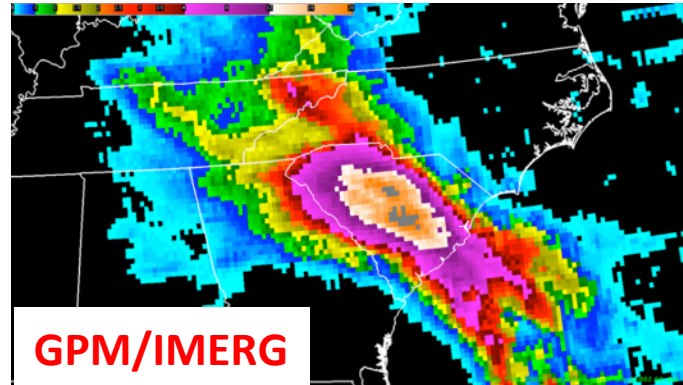
[Photo credit: Dave DuBois, NM state climatologist]

electric soil moisture

SPoRT-LIS Evaluation:

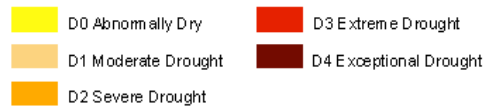
Soil Moisture Change in South Carolina Flooding

NASA's GPM satellite precipitation estimate captured 10-20"+ rainfall with some over-estimation (right)

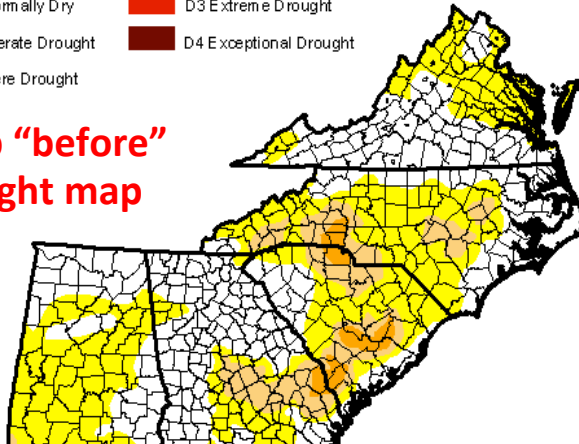


U.S. Drought Monitor Southeast

Intensity:

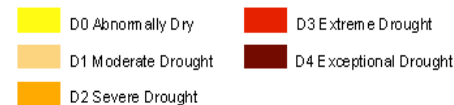


**29 Sep "before"
drought map**

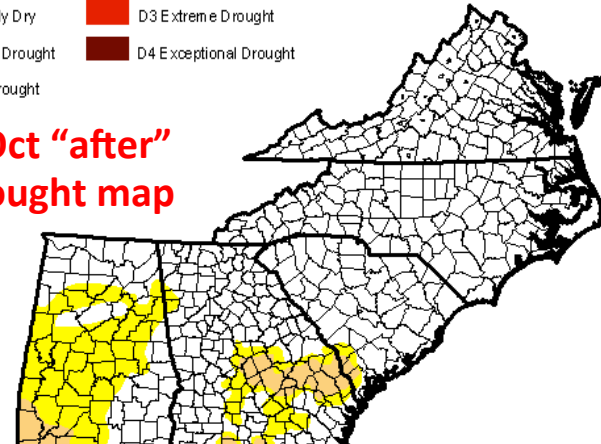


U.S. Drought Monitor Southeast

Intensity:



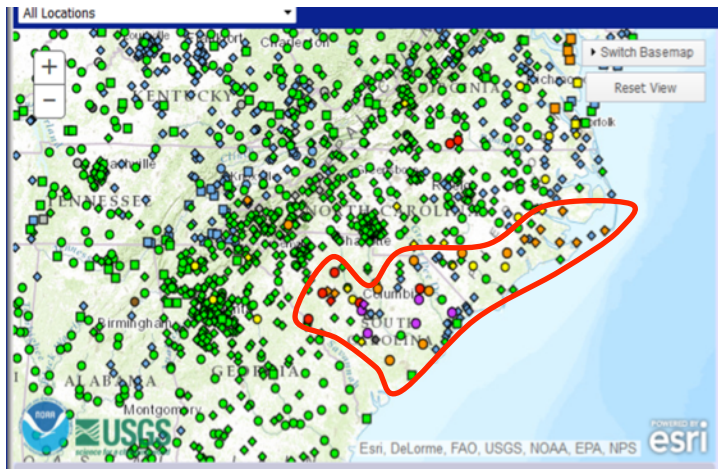
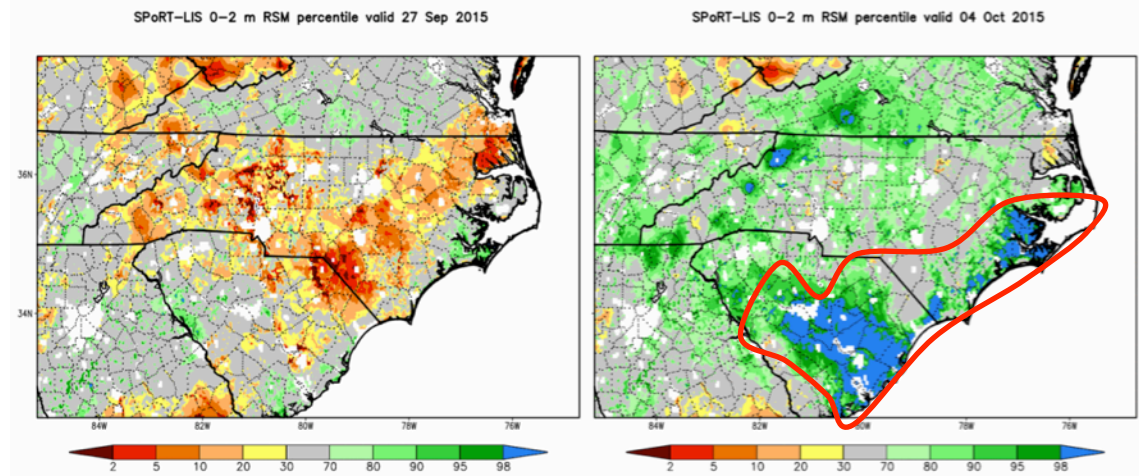
**6 Oct "after"
drought map**



SPoRT-LIS Evaluation:

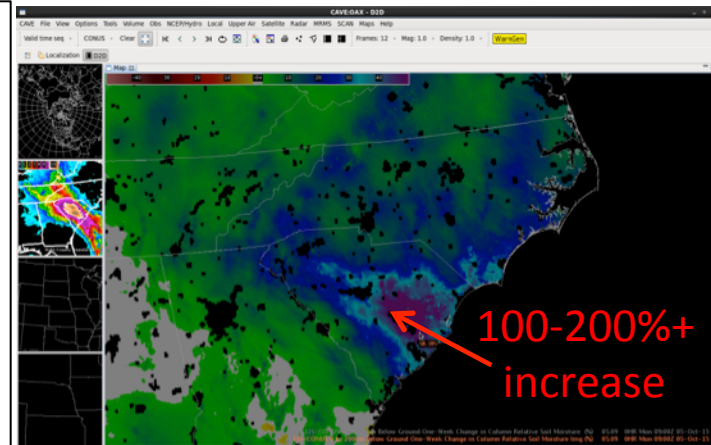
Soil Moisture Change in South Carolina Flooding, cont.

Total column relative soil moisture percentile before and after event (right images)



USGS river gauges indicating minor to major flooding (left);

One-week change in total column relative soil moisture displayed in NWS Huntsville AWIPS II (right)



Future Direction and Ideas

- **Future upgrades of SPoRT-LIS**
 - SMAP data assimilation: (See Blankenship et al. talk J11.2, 30th Hydro, Tue 11:15 am)
 - GRACE terrestrial water storage, SMOPS, others?
- **Collaborate with National Water Center and RFCs**
- **Run SPoRT-LIS coupled to regional NWP (i.e., NASA Unified-WRF) and/or hydrological models (WRF-Hydro)**
- **Verification:**
 - Use Land surface Verification Toolkit with available near-real time soil moisture observations
 - Monitor impacts of data assimilation and regional NWP